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THESIS

DESIGN OF A COMPUTER NETWORK TO IMPROVE INFORMATION QUALITY FOR THE INDONESIAN ARMY

by

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Data is currently collected from various Army units in remote areas, recorded by the Army Main Region Commands and Army Branches, and then sent to the Army Headquarters all via courier service. To improve the quality of Army's command and control and administration processes, the data must be accurate and timely. Therefore instead of sending the data manually via courier service, the data could be sent via electronic communication.

This thesis analyzes the data collection process and recommends that the Army's computers be integrated via LANs at each major command and that long-haul connectivity be establish via satellites in a star topology. The Department of Defense Communication Agency can provide Very Small Aperture Terminal (VSAT) service in single hop mode, and PT Lintasarta, a specialized data communication company, can provide data communication via Public Switched Packet Data Network (PSPDN) as a backup.

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Design of a Computer Network to Improve Information Quality for The Indonesian Army

by

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ABSTRACT

The Indonesian Army has used computers to gather information for over 20 years. Computers have been installed throughout the entire Army organization, from Army Headquarters down to Army Main Region Commands and Army Branches.

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I. INTRODUCTION

A. OVERVIEW

Information plays a significant role in every organization, including the military. The Indonesian Army has used computers to gather management information for 20 years; this dependence on computers forces the Army to continue to pursue technological advances. Computers have been installed throughout the entire Army organization: Army Headquarters has a mainframe computer, Army Main Regional Commands have mini-computers and other Army Branches use microcomputers. The main purpose of these computers is to support management at each command level and provide data collection for use by higher command echelons. Data is collected from the various Army units in remote areas (Fig.1), recorded by the Army Main Regional Commands and Army Branches, and then sent to the Army Headquarters via courier services. In the near future the demand for information is expected to increase significantly. This is due to a more dynamic environment, with rapidly changing elements requiring immediate actions. In the Information Age, whoever has the information first is the leader. Since the information product is a function of the data collected, the reliability of the data is very important. Unlike a banana tree, which can process garbage

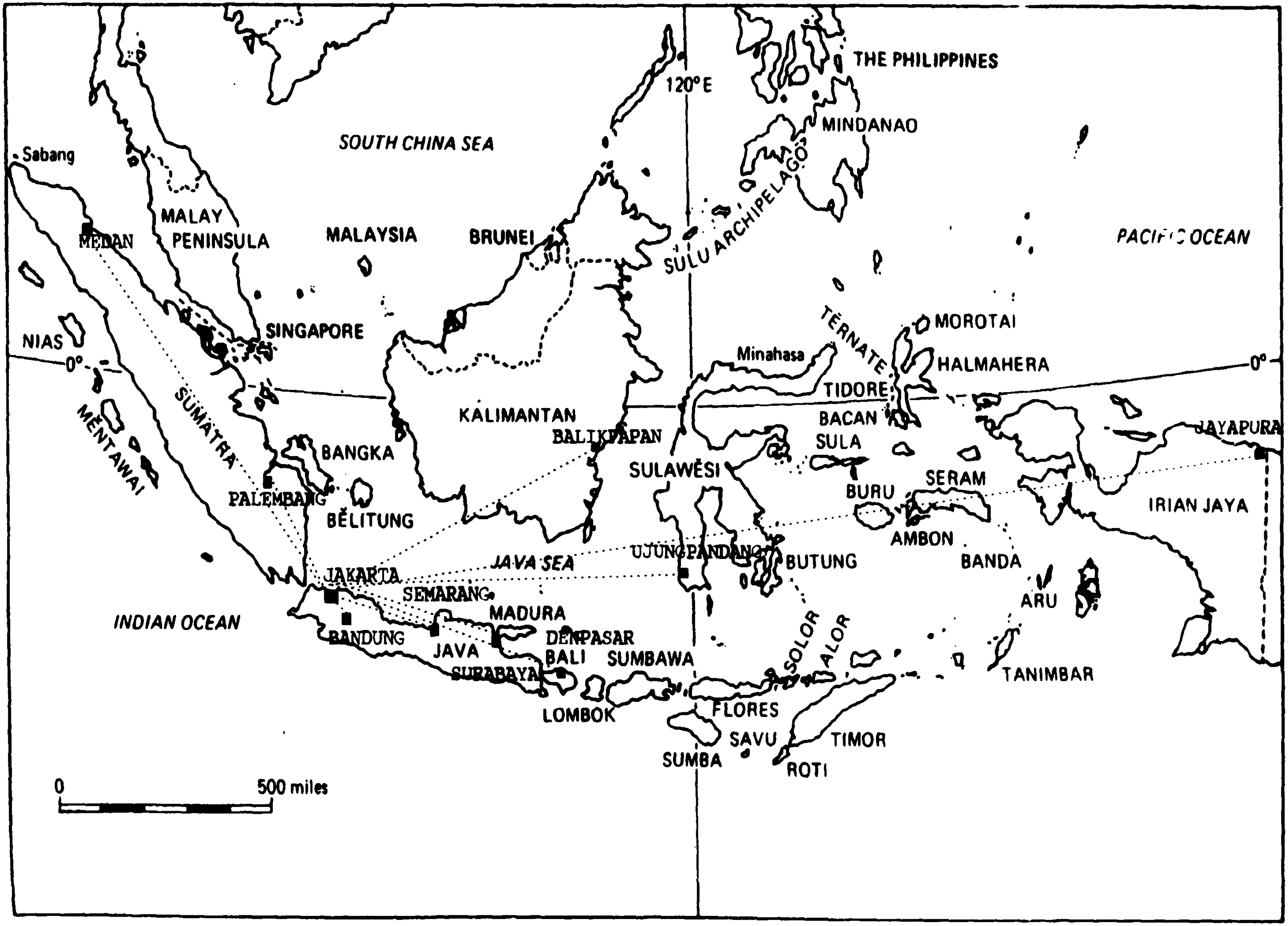

Figure 1. The Republic of Indonesia

and produce a sweet fruit, a computer will process garbage (data input) and still produce garbage as the output (although possibly in a different format).

Efforts to improve the quality of data collected have been emphasized year after year in every plan and budget prepared by the Army Data Processing Center. These efforts include reducing report redundancy, implementing simplified reports, and integrating interrelated files into a single database. Another method to provide improvements in information quality would be to change the way data and transactions are received from the field. Instead of sending the data manually via courier service, the data could be sent via electronic communications by integrating the Army's computers into a network.

B. OBJECTIVE

The objective of this thesis is to analyze the methodology for connecting all the Indonesian Army's computers into a network using communication carriers that are currently available. This thesis will also determine the future enhancements required to implement technological advances in computer hardware and software and expected development of the Army's communication networks.

C. RESEARCH QUESTION

The primary research question is: how would an integrated computer network be developed for the Indonesian Army? This question is supported by the secondary research questions:

- What is the Army's existing and future network architectures and implementations?
- What are the possible network configurations?
- What are the most appropriate transmission and switching techniques?
- Who could provide the networking support?
- What are some possibilities for future enhancements?

D. METHODOLOGY

This research will include a study of the related literature in the US and Indonesia, evaluate previous studies in the area of computer networking in the US, and develop a recommendation for the Indonesian Army's Networking System Architecture.

E. SCOPE

Computer use in Indonesian Army is rapidly gaining momentum. This thesis will serve as a management guidance in building a computer communications network and keeping computer networking on track for the next decade. This thesis will cover:

- Networking multiple computer hardware platforms.

* Computer networking implementations.
* Enhancement possibilities in the future.

Instead of using the full titles Indonesian Army and Indonesian Department of Defense, the abbreviated titles Army and DOD will be used to refer to these organizations throughout the entire thesis. All other organizations will be fully specified.

II. NETWORK ARCHITECTURE OPTIONS

A. NETWORK CONFIGURATION

There are several ways to configure a computer network depending on the geometric arrangement of the communication links and nodes. Multiple network configurations provide flexibility of choice with respect to reliability, data traffic load, and economic feasibility. Five topologies will be discussed: bus, ring, star, multidrop, and mesh topology. (Sharma, 1990,p 8).

1. Bus Topology

A bus (Fig.2) is a single communications channel shared by several nodes connected together › form a network.

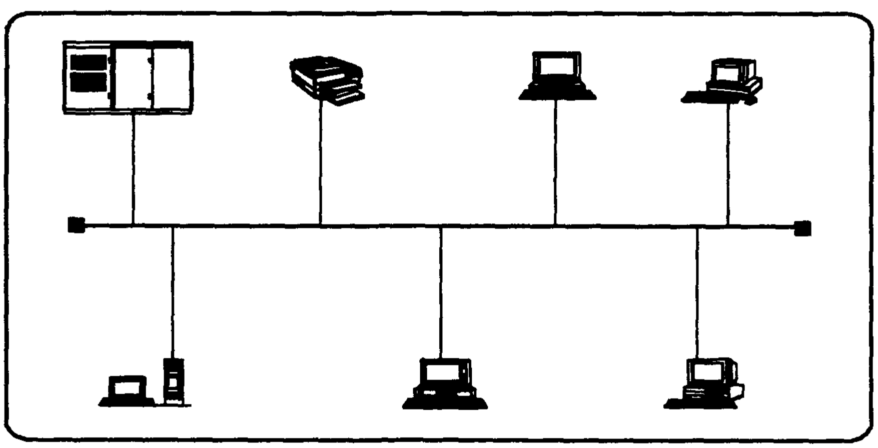

Figure 2. Bus Topology

This topology is generally used only for local area networks and works better for a small number of nodes than for a large numbers of nodes.

2. Ring Topology

A ring topology (Fig. 3) is a network with several nodes connected together in a contiguous circle as a ring. This topology is normally used in local area network environments. One advantage is that the transmitted signal is regenerated in each node (Stalling, 1994, p 365); transmission errors are thus minimized, but the network will be slower. This topology works very well for a small number of nodes, yet still works well for a larger number of nodes.

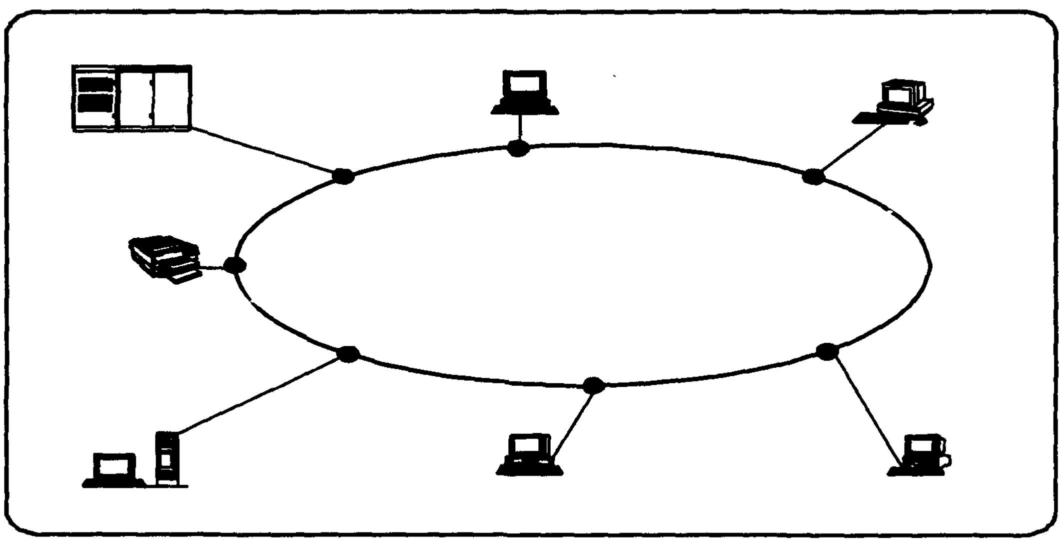

Figure 3. Ring Topology

3. Star Topology

In a star topology (Fig. 4) all data traffic between individual computers goes through a central computer, or is

controlled by the central computer. Traffic is from the central computer to the surrounding computers. In the local area network implementation, the central computer can also recognize the different priorities assigned to the computers in the network.

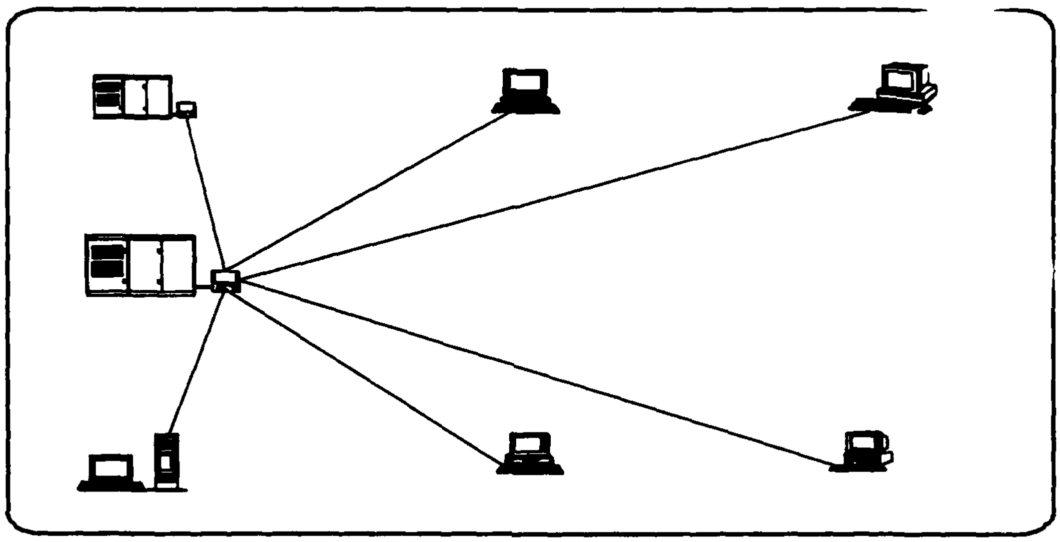

Figure 4. Star Topology

These networks tend to follow the hierarchy of the organization, with the central computer as the most powerful and the other computers belonging to lower hierarchies of the organization.

4. Multidrop Topology

Multidrop is a form of bus topology which is used in wide area networks. The key design feature is the connection of individual nodes by determining the minimum total length of the links. (Fig. 5) Krushal's and Prim's minimal spanning tree

algorithm (Sharma, 1990, p 110) can be used to find the minimum length links (without weighing constraints): 1) start with all unconnected nodes; 2) make connection between two closest node to make a cluster; 3) connect the closest other nodes or clusters until all nodes are connected to form a network, but without making a circle.

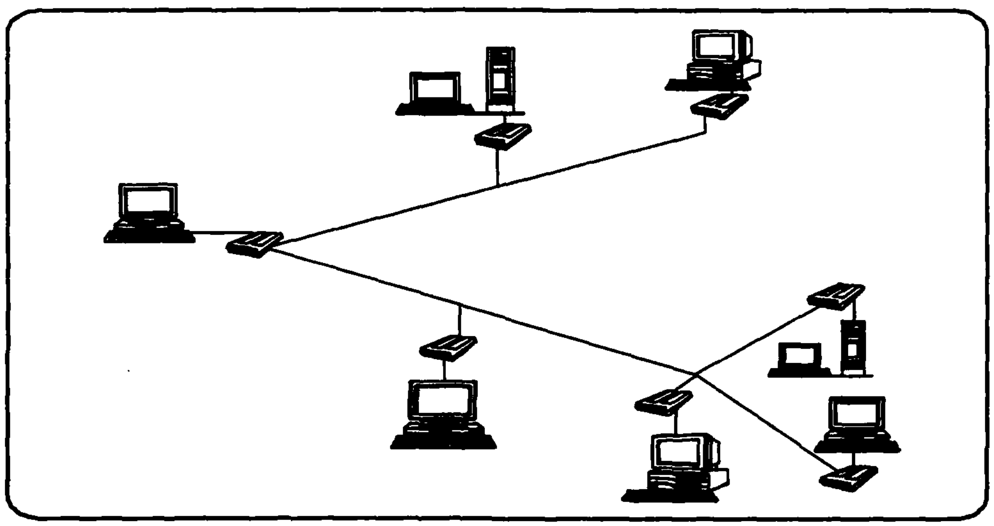

Figure 5. Multidrop Topology

5. Mesh Topology

A mesh topology (Fig. 6) defines a network where every node is directly connected to every other. The number of paths (links) and connections (ports) can be determined as $n(n-1)/2$ links and $n-1$ ports for n nodes. Mesh topology is good for a network with a small number of nodes and high node interdependency (i.e., the traffic load among nodes is high).

Another consideration is the redundancy of links allows a separate link path as a backup link if the direct link fails.

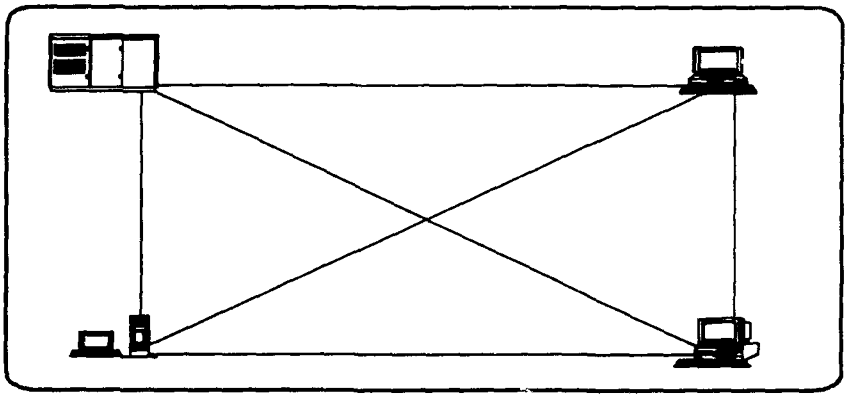

Figure 6. Mesh Topology

B. PROTOCOL STANDARDS

Protocols have an important role in the communications between computers. They can successfully communicate only if they speak the same "language". They must conform to some convention, or protocol, which may be defined as a set of rules that regulate the exchange of data between these computers. Protocols can perform several functions, and not all protocols cover all functions. Some of the protocol functions are:

- Segmentation and reassembly. The sender divides messages into several segments called Protocol Data Units (PDU) and the receiver reassembles this PDU into a message.

- Encapsulation. Wraps the segment with address (sender and receiver identification), error detection code and some other controls.
- Connection control. Connectionless oriented (without a physical connection) or connection-oriented (establish physical connection) data transfer.
- Flow control. Ensure the segments sent are received before sending the next segments.
- Error control. Ensure there is no lost or damaged segments during transmission. Several techniques are used; one simple technique is retransmittal of the data after a certain amount of time if no acknowledgment is received by the sender.
- Addressing. Specific and unique address must be provided for each individual station in a network in order to send or receive data.

Protocol standards have significant implications in the networking arena. Consider the case where there are four sources and three destinations to be connected. Each source would use a different protocol for each destination. This would require 12 protocols and 24 protocol implementations. With a standard protocol, only one protocol and seven protocol implementations are required. (Stalling, 1994, p 424). By having a standard protocol the user has the flexibility to choose different kinds of computers and equipment from multiple vendors to communicate.

1. Proprietary Standards

Each major hardware vendor has developed its own protocol standard. This theme works well as long as the network consists of homogeneous computers from the same vendor. Any other computer that does not follow this vendor's protocol will be unable to communicate. The advantages of a homogeneous system include a simplified network interface and no need to assign people to study different computer hardware. The disadvantages are: the degree of dependency to one vendor is very high with increased risk of non-support if something happened to the vendor; an inability to take advantage of competition in the market; and difficulty adopting changes in technology or hardware. The computer industry is changirg rapidly, and proprietary standards would require new protocol interfaces every time the customer's needs caused a change in hardware. Examples of proprietary standards are discussed below.

a. *System Network Architecture*

Popularly known as SNA, this protocol standard was first announced by IBM in 1974. SNA has become a de facto standard and non-IBM computers can connect to IBM machines under SNA through software that allows emulation of IBM machines. SNA consists of seven layers (Fig. 7) (Stallings, 1994, p 462).

• Physical Control. Responsible for the physical interface specification between nodes. This physical interface can use serial (EIA-232-D) or parallel mode (S/370 channel) using interoperable protocols.

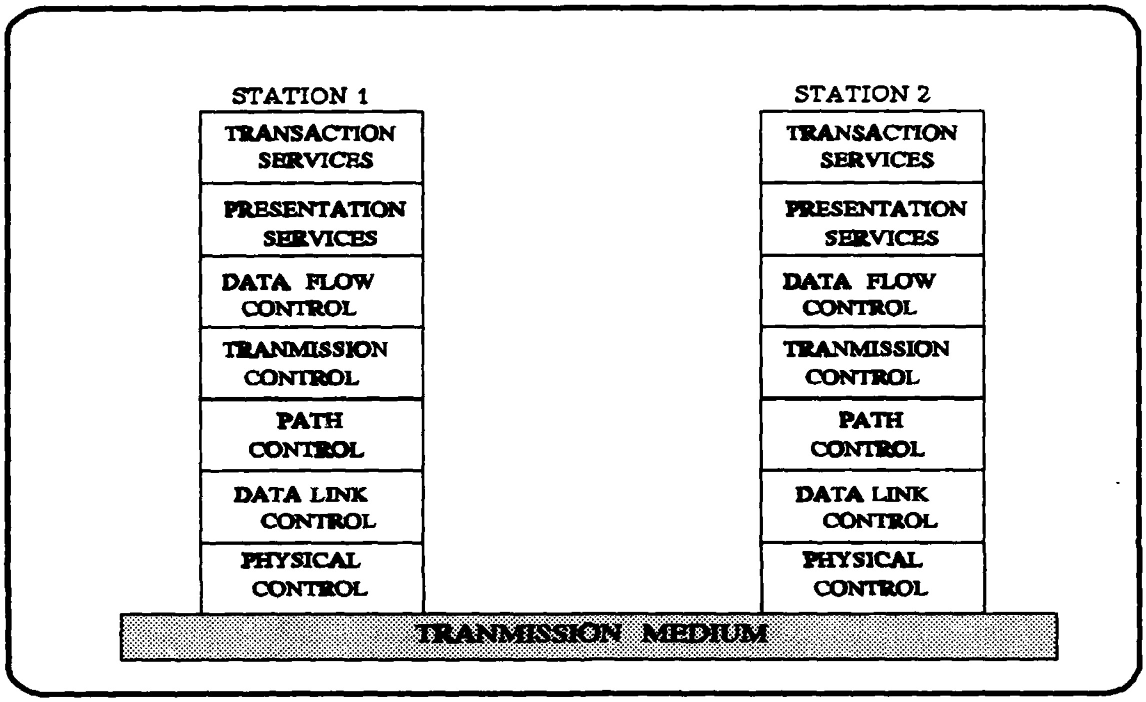

Figure 7. SNA Layer

• Data Link Control. Provides reliability of the data transfer across the physical link by adding a link header and link trailer to messages, and provides for error correction and recovery. Protocol for serial link is SDLC (Synchronous Data Link Control), for parallel is S/370 data channel protocol.

• Path Control. Responsible for segmenting messages in the sender and routing it to the receiver by sequencing and blocking the messages.

- Transmission Control. Responsible for establishing, maintaining and terminating SNA communication session.
- Data Flow Control. This layer provides services that are visible to the end user, such as full duplex or half duplex contention and response options.
- Presentation Services. Function of this layer is formatting the different views of data exchange, and data compression for speed of transmission.
- Transaction Services. Primarily provides network management services; these include configuration, network operator session, and maintenance management services.

b. Digital Network Architecture

This proprietary standard was built and introduced by Digital Equipment Corporation (DEC) in 1975. DEC DNA is the standard structure for DECnet network products and supports the flexible interconnection of Digital's family of computers. DNA was designed to provide greater flexibility for user applications. It can use a wide range of communication facilities and is thus very cost effective. DNA structure consists of 6 hierarchical modules (Fig. 8). Each module can be independently replaced by an equivalent (non-DNA) module as long as it has the same function (Green, 1983, p 256). The functions of each layer are as follows:

- Physical Link Layer. Responsible for managing the physical transmission of data over the media. Depending on the

characteristics of the media used, it defines the signaling technique, clocking, and the interfaces between the computer system and the communication carrier. An example protocol standard used is EIA-232-D.

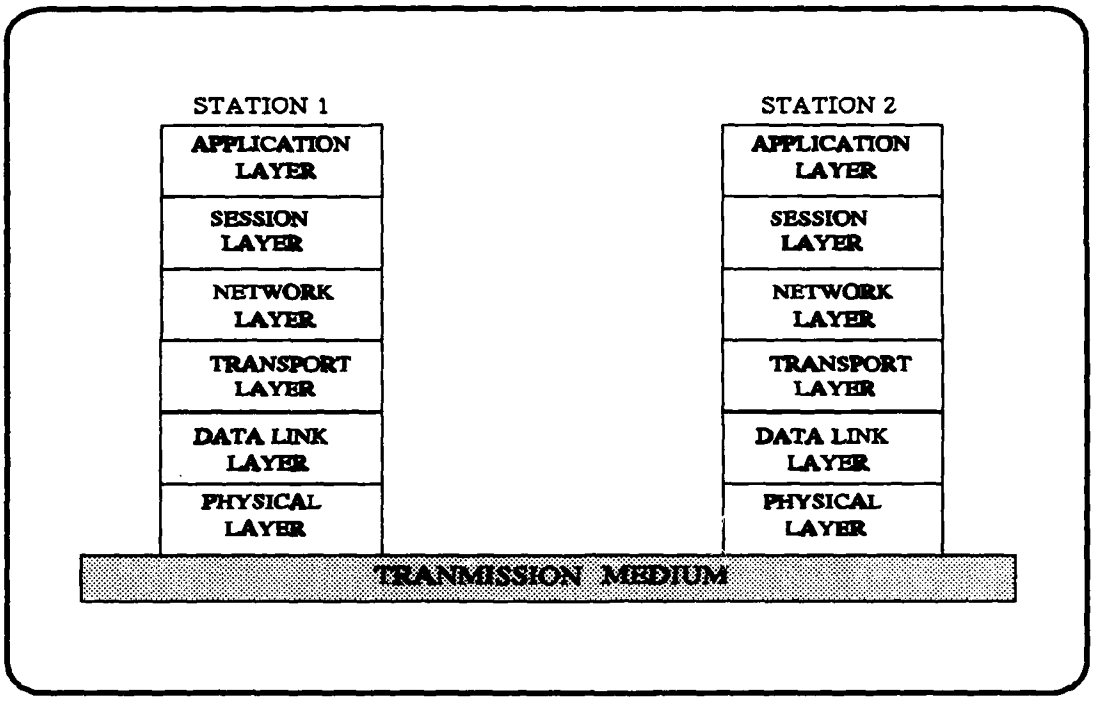

Figure 8. DNA Layer

- Data Link Layer. Responsible for message framing, channel management allowing for half duplex point-to-point or multipoint channel data integrity and sequencing over the channel.
- Transport Layer. This layer is responsible for routing the messages to the destination, controlling the traffic flow

to guarantee that the link is not overloaded, and controlling the lifetime of a message in the network.

- Network Services Layer. The functions of this layer are : error control and sequencing, flow control from the sender to the receiver, and segmentation of large messages into smaller segments with subsequent reassembly back to messages at the destination.
- Session Control Layer. This layer is responsible for address translation, local process addressing, generic addressing and security and authority functions.
- Application Layer. This layer provides flexibility for user application programs.

2. Open System Standards

The idea of having an open system standard is to provide the means for heterogeneous computer systems to be connected and communicate with each other in an easy way, to be combined into an integrated operating environment, and to provide application portability. The interconnection of different platforms can be achieved if all of those computers are provided with the same protocol standard. The difference between open system standards and proprietary standards is in the hardware and software interdependency: open system standards are vendor independent protocols that are portable to any kind of hardware; proprietary standards are heavily hardware and software dependent. Open system standards are

normally developed by international organizations such as the International Standard Organization (ISO), the International Telecommunication Union (ITU) and also by potential users such as the United States Department of Defense. A computer vendor will develop hardware and software that complies with those standards, even if it requires an extra investment, in order to satisfy their customer and get into the highly competitive market. The two open system standards are explained below.

a. Open System Interconnection

This system is well known as the OSI Reference Model (OSIRM) and was developed by the ISO. The ISO is a non-profit organization, whose membership is voluntarily drawn from more than 90 countries. The first version of the OSIRM was announced in 1983 even though the details were incomplete (Tang, 1992, p 17). Since then, several addenda have been added to firm up the model and to support user requirements. The OSIRM divided communication functionality into a hierarchical seven layer model (Fig. 9).

- Physical Layer. Provides the specifics for the mechanical, electrical activation, maintenance and deactivation of the physical connection for a serial bitstream data link connection. Other functions include synchronization and multiplexing. The common physical interface standards are EIA-232-D and CCITT X.21.

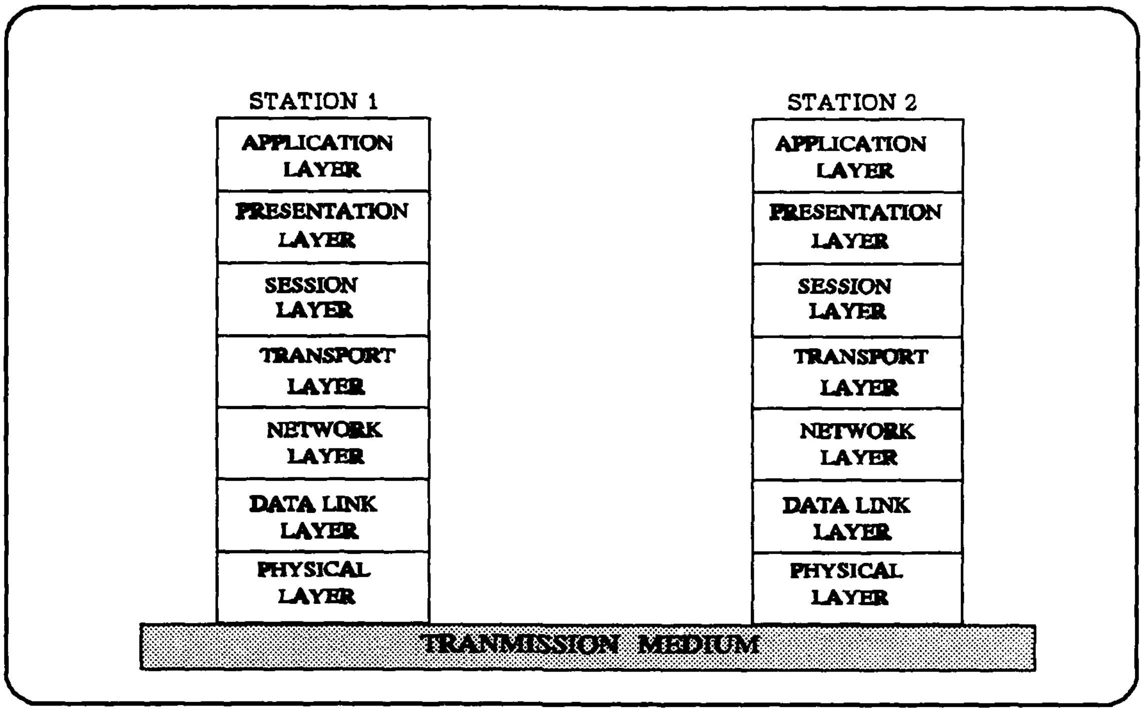

Figure 9. OSI Layer

- Data Link Layer. This layer performs link establishment, error detection and recovery, and flow control.
- Network Layer. Provides a global addressing scheme and performs routing and relaying. This is the most complex layer because the protocols have to satisfy many different kinds of networks.
- Transport Layer. Provides a reliable end-to-end transport service to the users. Transport functions depend on the network reliability. ISO has identified five different protocols related to the desired reliability of the network, TP0 - TP4. TP0 is for the most reliable network, TP4 is for the least reliable network.

- Session Layer. Performs the functions of organization and synchronization of the dialogue between two communicating users, and management of the data exchange.
- Presentation Layer. Primarily used to handle the representation of information exchanged between two communicating systems even when both have different local representations.
- Application Layer. The highest level layer that directly serves the application by providing the required communication interface. Some examples of applications are electronic mail and file transfer.

b. Transmission Control Protocol/Internet Protocol

Also known as TCP/IP, this protocol was developed by the United States Department of Defense. In the early 1970's, the US Defense Advanced Research Project Agency (DARPA) sponsored the team work to develop a network standard for multiplatform connectivity, by learning the details of how computers communicate, and developing a set of conventions for interconnecting networks and information routing in the network (Minoli, 1991, p 630). This protocol has been adopted and supported by many vendors of mainframe, mini and personal computers, and has become very popular, achieving de facto standard status. TCP/IP currently divides networking into four layers (Fig. 10) (Newton, 1994).

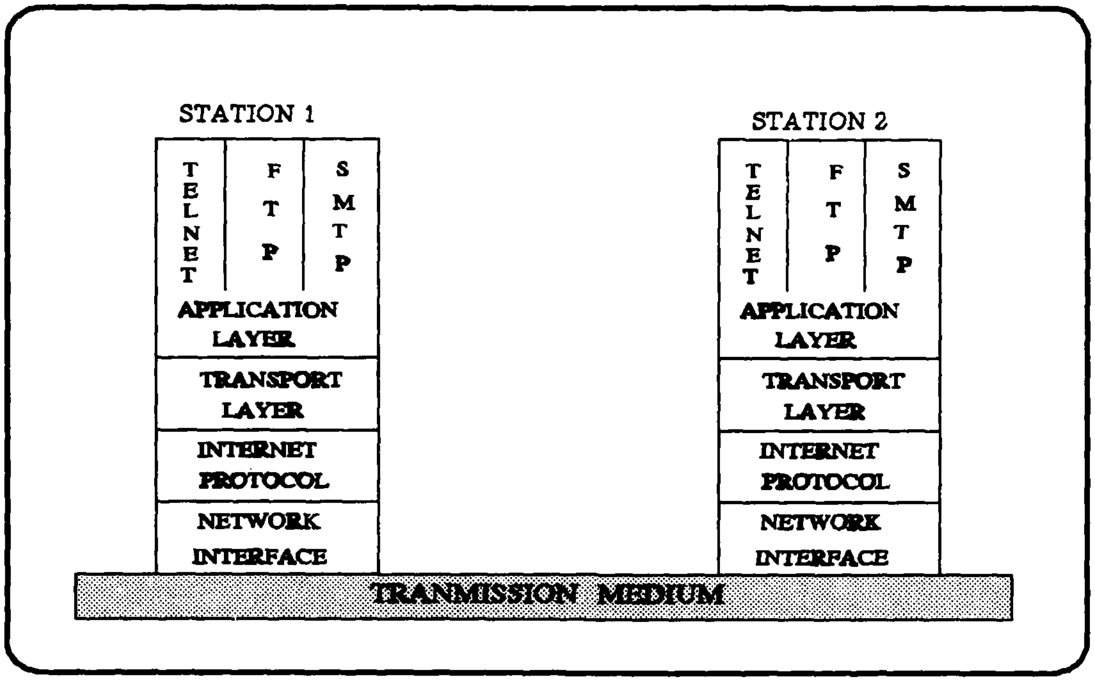

Figure 10. TCP/IP Layer

- Network Interface Layer. This layer is related to the physical layer in the OSIRM protocol and is responsible for managing the exchange of data between devices in the network.
- Internet Layer. Provides the addressing needed to allow routers to forward packets across multiple networks in an internet. Using connectionless datagram services, an attempt is made to deliver every packet to its destination, but this layer is not responsible for retransmitting the damaged packets.
- Transport Layer. This layer is the most well known within the protocol and is responsible for end-to-end connectivity between sender and receiver. This layer

performs error control with detection and recovery of lost or corrupted packets. TCP divides message blocks into segments and provides a sequence number in order to reassemble the message by the receiver.

- Application Layer. This layer manages the functions required by the user program and includes the protocol for remote login (TELNET), file transfer (FTP) and electronic mail (SMTP).

3. Army's Existing Protocol

The Army installed an IBM S/4341 in the Army data processing center and two IBM S/4331's in the Army Main Region Commands. They were installed in the early 1980's. Three additional mini computers, Honeywell-Bull DPS-6, were then purchased and installed in other Main Region Commands. To complete the automation of the remaining Main Region Commands, three mini computers, Prime 2115, were purchased and installed. IBM SNA was chosen as the Army's standard protocol. The non-IBM computers installed software to emulate a cluster type IBM S/3174 remote controller and emulate their terminals as IBM 3270 dumb terminals. Although communication was possible between IBM and non-IBM computers, this arrangement was not very efficient. Communication between IBM computers was fine, but communication between IBM and non-IBM computers was master to slave (non-IBM terminals can remotely

login to IBM computers, but not vice versa). Even between IBM computers, file transfers never succeeded. Under master-slave communications, no remote logins or file transfers were possible. These conditions remained unchanged throughout the life of these computers. The mainframe and minicomputers have now become obsolete and are difficult to maintain (due to the high cost of maintenance and software rental). This status quo will remain until the end of the fiscal year 1994/1995, when management is expected to buy a new computer system to substitute for the old one. The standard is expected to be IBM SNA, although the Army management team can decide on a different standard.

C. SWITCHING TECHNOLOGY

The primary purpose of a switch (Fig. 11) is to provide a means for users to connect and communicate with every other user in the network. Suppose there is no switching in the network; then every user must be directly connected to every other user; this is not practical nor economical due to the huge cabling requirements and difficulty connecting across long distances. Since the telephone was invented, there has been an evolution in technology, from analog systems to digital systems. First generation systems (1890s - 1950s) were all analog. Second generation systems (1960s - early 1970s) were still mostly analog although the digital system was emerging. During the third generation of evolution (mid

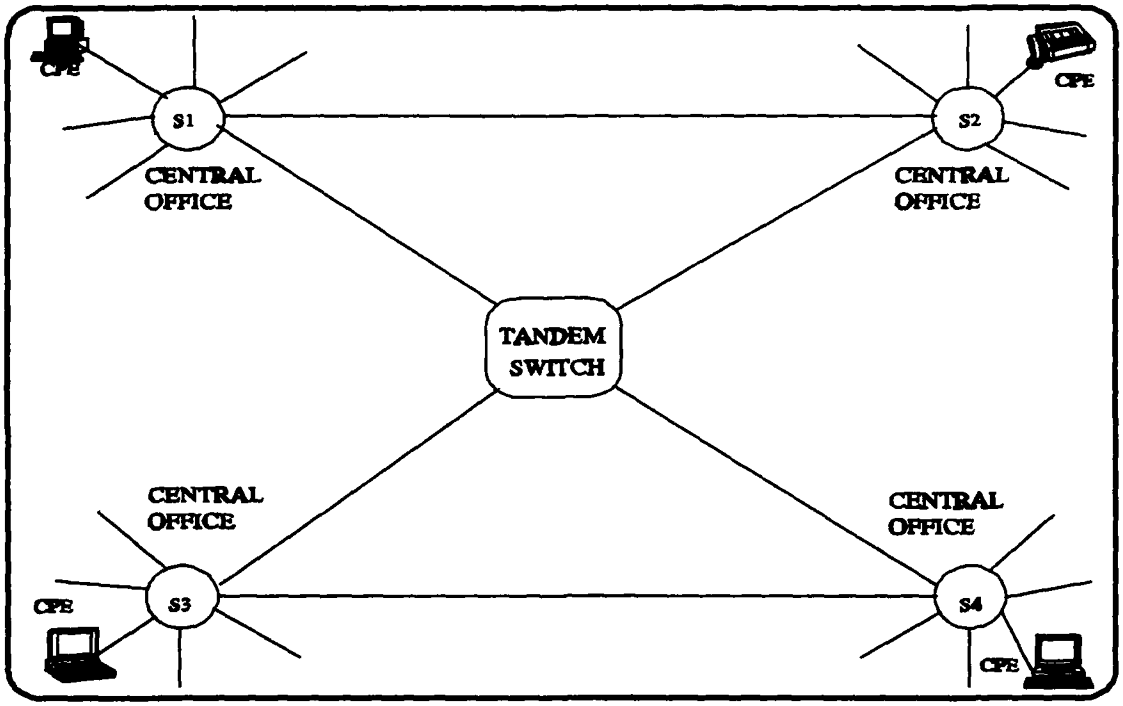

Figure 11. Switching

1970s - 1980s) digital systems were introduced. By the fourth generation (early 1990s), Integrated Service Digital Network (ISDN) was introduced for end-to-end digital connectivity, and in the fifth generation (late 1990s) end-to-end broadband digital communication is expected to be introduced (Minoli, 1991, pp 28-29). Most of today's networks between switches are digital, but the connection from CPE (Customer Premises Equipment) to the switch is still analog except by special request (Minoli, 1991, p 39). In analog communications, connecting a computer/Data Terminal Equipment (DTE) to the communication circuit requires a Data Communication Equipment such as a modem (modulator-demodulator). The digital stream from DTE will modulate the analog carrier at the sender;

receiver needs a demodulator to restore the signal to digital format. In a digital transmission system, the network can directly accept digital streams, but each computer still needs a network termination device. Switching methods will be discussed below.

1. Circuit Switching

This is the common method used for telephone systems. It involves a dedicated path link between two nodes for the required communication time including the time to establish the connection, exchange/transfer data, and disconnect. Although this method is primarily used for telephone communications, it is also applicable for data communication. There are some advantages and disadvantages of using circuit switch methods for data communication. Some of the advantages are: the sender and receiver are recognized (gives the assurance that the message is going to the right address), less overhead for segmentation (send the whole message), and less delay time. The disadvantages are: if the connection is lost, the whole message must be retransmitted, and the cost of using circuit/path is more expensive. The circuit switching is illustrated in Figure 12.

2. Packet Switching

Early data communications were based on techniques for voice communication, applying circuit switching technology. As the amount of data communication using circuit switching

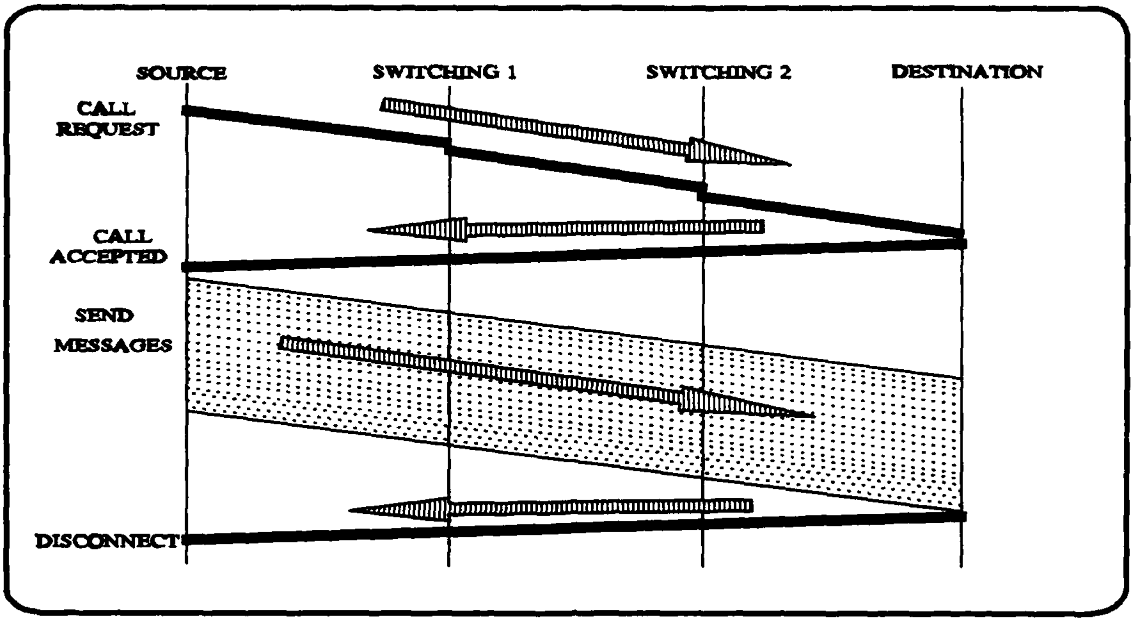

Figure 12. Circuit Switch

increased, two problems developed: first, in the terminal to host connection, the connections are idle for long periods of time (inefficient) while the operator types or reads information on the screen; second, the sender and receiver must employ the same data rate, limiting the ability to internetwork using different kinds of computers with different data rates. To solve this problem, packetized messages are used. A message is divided into smaller packets and each packet is provided with several controls such as the source address, destination address, error control, flow control, etc. Packets are sent through the network from source to its destination and reassembled into the message format. Packet switching has a number of advantages: (Stallings, 1994, p 274)

- Greater efficiency in using a transmission line since a single link between nodes can be shared by other packets.
- Data rate conversion is possible allowing a variety of data rates to be used with synchronization when two parties make connection.
- No calls are blocked, as in circuit switching. Packets are accepted, but the delay increases.
- Priority traffic controls allowing the higher priority system to send the packet before the lower one.

There are two techniques used in packet switching as discussed below.

a. *Datagram*

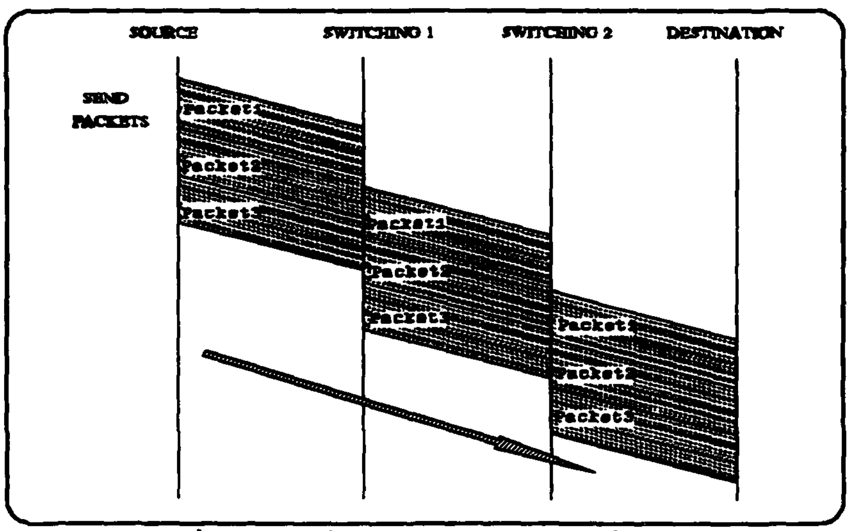

Figure 13. Datagram Packets

Each packet is independent; there is no reference about the previous or the next packet included as part of a message. Each packet will be delivered to its destination

through any route that is available and possible (Fig. 13). This results in less delay and less traffic query in a certain route. When the packets arrive, no sequencing is performed. In the worst case, the receiver will not know if some of the packets are lost due to an intermediate node failure.

b. Virtual Circuit

Before data transmission can occur, the virtual (not real/physical) path must be established. The routes are predetermined and the receiver sends acknowledgment when it is ready. All the packets are sent sequentially through the same route, therefore there is no need for routing decisions to find the best available route. When all packets are received, the receiver terminates the connection (Fig. 14).

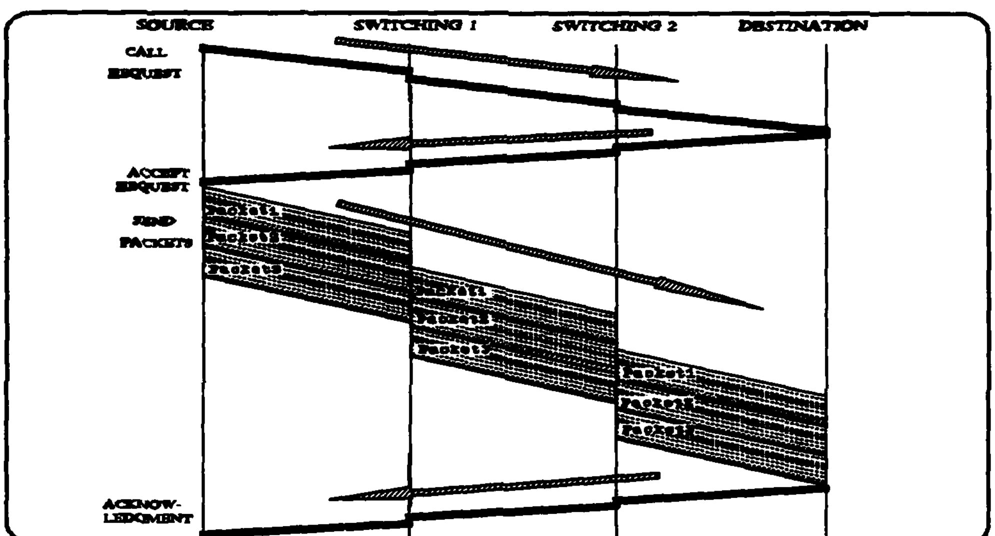

Figure 14. Virtual Circuit

This method is similar to circuit switching throughout the duration of the logical connection; but since delay time can

be used by other packets from different nodes, it is more efficient in utilizing the path.

3. Fast Packet Switching

Traditional packet switching requires a message to be bundled with overhead such as error and control checking to ensure that data is exchanged correctly through a noisy transmission medium. Today's fiber-based wide area networks are relatively error free, with routers and computers already handling end-to-end error and flow control. The next step is to simplify the transmission protocol by accepting data from the source and delivering the data to the destination without error checking. This is the basic idea behind fast packet switching. Two types of fast packet switching have been introduced: frame relay and cell relay.

a. Frame Relay

Frame relay is defined by CCITT Recommendation I.122 for three distinctive services: Frame Relaying-1, Frame Relaying-2, and Frame Switching. Traditional packet switching is operated up to 64 Kbps; frame relay operates at high speeds up to 2.048 Mbps. It has a variable-length packet architecture, and is good for high speed bursty data transmissions over wide area networks. Frame relay does not support voice and video, because voice and video are highly sensitive to variations in the transmission delay. The architecture specifies that frame relay use switched virtual

circuits and permanent virtual circuits (no need for call set-up establishment). Frame relay is using proven technology packet switches and will be implemented over an Integrated Services Digital Network (ISDN will be discussed in Chapter III).

b. Cell Relay

This technology is a fully digitized network which will be based on fiber optic links which have high data rates (100 Mbps or more) and will implement the Broadband Integrated Services Digital Network (B-ISDN, to be discussed in Chapter III). Cell relay uses a fixed size packet and is also known as Asynchronous Transfer Mode. ATM was first introduced by the CCITT Recommendation I.121 in 1988, and has been strongly promoted as the transport structure for the future broadband telecommunication network. Some characteristics of the ATM are:

- Fixed packet size. Each packet is 53 bytes long with 5 bytes for header and 48 bytes for data.
- Connection oriented packets are sent through a virtually connected circuit.
- No error and flow control required on the links, since fiber optic is an almost error free medium, with error probabilities in the order of magnitude $10^{-9}$to 10^{-12}.

- Ability to handle different types of traffic, with respect to ATM Adaptation Layer (AAL); AAL type 1 & 2 for Video or Voice, AAL type 3, 4, & 5 for data.

ATM will be a good solution for high speed data transmission including motion pictures, data and voice signals all transmitted together.

III. TELECOMMUNICATION OPTIONS

A. SWITCHED SERVICES

1. Public Switched Telephone Network (PSTN)

Public Switched Telephone Network (PSTN) is the most common communication service available in the world, including Indonesia. Telephone lines were originally designed solely for voice communication. As the requirement for data communication developed, telephone lines were used to transmit binary data (0's and 1's) as well as voice. As the demand for data communication grew, regular telephone lines were not sufficient for these requirements. Therefore the telephone companies developed and provided special services for data communications, based on either analog or digital transmission. Digital transmission provides much faster data transfer rates when compared to analog transmission.

Most telephone line is unshielded twisted pair (UTP) because it is economical and sufficient for the telephone services that carry analog signals or voice in 4 Khz bandwidth channels.

Data transmission capacity is a function of channel bandwidth; the bigger the bandwidth, the higher the data rate that can be achieved. The relation between bandwidth and capacity (Stallings, 1994,p 64) is represented in the formula:

$$C = W \log_2 (1+S/N)$$

where C = the data transmission capacity of the channel in bits per second, W = bandwidth of the channel in hertz (cycle/second), and S/N = signal to noise ratio (in the channel). For PSTN channel, we have W = 4 Khz, and S/N = 30 dB or ratio 1000:1. Thus the maximum data rate $C = 4000 \log_2 (1+1000)$ or 40 Kbits per second is obtained. PSTN is offered by the state owned company PT TELKOM (TELKOM Ltd.= Indonesia Telecommunication) for national telecommunications.

2. Packet Switched Public Data Network (PSPDN)

This service, called SKDP (Sambungan Komunikasi Data Paket = Packet Switched Public Data Network), is offered by PT Lintasarta based on the standard interface protocol International Telegraph Telephone Consultative Committee (CCITT) X.25 (interface protocol between packet switch DCE equipment and packet mode DTE) (Lintasarta1, 1993). As explained in Chapter II, this type of data communication use involves a virtual circuit. Two types of connections to PSPDN are offered :

a. Dial-up

To establish communication, customer must dial a local number in order to connect to the PSPDN switching network. Then the network will be responsible for delivery of the data over their network to its destination. Data rate for this service is 300 bps up to 1200 bps, in asynchronous mode.

b. Dedicated services

A customer's computer is directly connected to the PSPDN switching network through the regular telephone network. When the customer wants to send data, he does not need to establish a dial-up connection with the network. The data rate for this service is 300 bps up to 4800 bps in asynchronous or synchronous mode.

For both type of services, PT Lintasarta provides the modems, and customers pay rent for the modem. The fee is based on duration time (for dial-up) or fixed monthly charge (for dedicated services), and the installation charge (Table I).

TABLE I. COST ESTIMATION FOR JAKARTA - SURABAYA

COMPONENT	PSTN		DOV	PSPDN		VSAT	
	DIAL-UP	LEASED L		DIAL-UP	LEASED L	SINGLE H.	DOUBLE H
Modem (Buy/Rent)	2,000.00	2,000.00		25.00	25.00		
Duration Charge (20 hours/month)	300.00			50.00			
Initial Charge			1,500.00			2,500.00	3,700.00
Monthly Charge	25.00	1,000.00	3,200.00	55.00	125.00	3,220.00	6,120.00
Blocks Data Transfer Charge (10 Mb/month)				750.00	750.00		
Customer Premise Preparation Cost			1,000.00			1,000.00	1,000.00
TOTAL COST	2,325.00	3,000.00	5,700.00	880.00	900.00	6,720.00	10,820.00

3. Integrated Services Digital Network

Integrated Services Digital Network (ISDN) is one of the concepts developed to answer the demands of universal services: transmission of voice, video (except motion picture), data, facsimile, image, and graphics information over digital channels. Universal service needs were first recognized in 1970, and eventually led to the development of this multichannel technology. In 1984 CCITT study group XVIII created recommendations for the development and implementation of ISDN (Minoli, 1991, p 170). This technology is an evolution of the public telephone network, resulting in end-to-end digital links. From a customer's home to the telco's central office the digital loop is over traditional unshielded twisted pair. Traditional data transmission uses a modem to convert data for the analog channel. With ISDN, digital data transmission does not need to be converted. It is also more efficient since the signal remains digital throughout the channel from end-to-end. Analog signals can only be amplified; if there is a noisy channel, the signal and noise are both amplified, and the error increases. But in a digital channel the signal can be regenerated to make it seem like the same signal as transmitted from the source. ISDN channels consist of 64 Kbps data channels (B=bearer) and 16 Kbps packet signalling channels (D=delta). Services are offered as a base rate 2B+D (two B channels and one D channel), or a primary

rate 23B+D (23 B channels and one D channel). ISDN is being implemented in Indonesia. In 1988 Indonesia launched a $4.5 billion program to introduce ISDN to expand and improve telecommunication services (Soegito, 1992, p 135).

4. Broadband-ISDN

There is a dramatic difference between ISDN (also known as Narrowband ISDN) and Broadband ISDN (B-ISDN). B-ISDN will use fiber optic cabling to the home, instead of using UTP as in ISDN. This fully digitized channel will answer the demands of multirate signal voice, data, video (including motion picture), image, and graphics information. High speed data transfer rates will be possible due to virtually unlimited bandwidth of fiber optic. Fiber optic is considered to be virtually error free, so it is not necessary to provide such overhead as error and flow control. Data rates of B-ISDN services will be about 150 Mbps or more, using Asynchronous Transfer Mode (ATM) technology (Fig. 15). When this technology will be available and how it will be implemented in Indonesia is still under discussion.

B. DEDICATED SERVICES

1. Dedicated Analog Services

Dedicated services use the regular telephone lines that are already installed by PT TELKOM from the local central office to the customer's premises. To use this system for

data communications, a customer must provide modems for both ends.

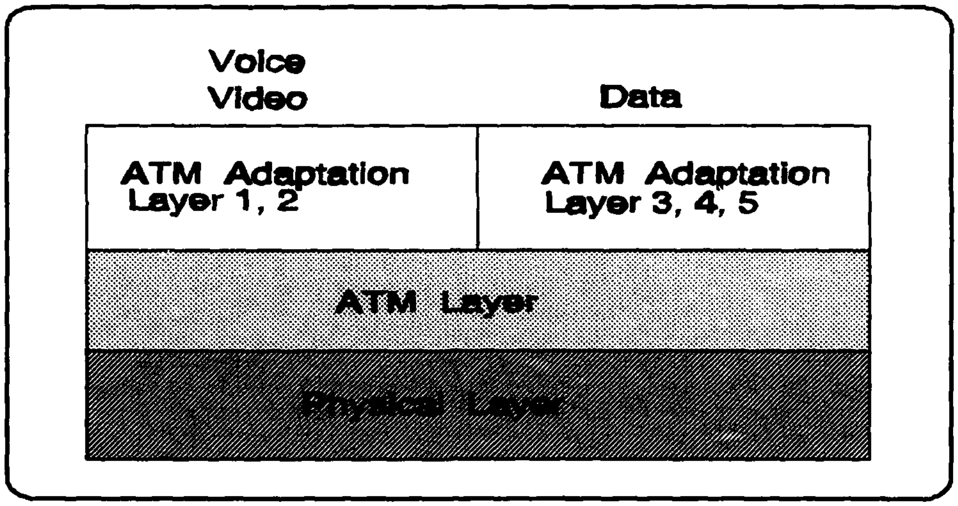

Figure 15. ATM over B-ISDN

Dedicated voice grade transmission services are compared with PSTN dial-up services as follows: PSTN is more economical if the customer's frequency of transmitting data is at most one hour per/day (Table I). The reliability of this service is very low; the channel is normally very noisy, especially with crosstalk and other interference. The Telcos claim no responsibility for data errors and recommend use for data transmission less than 1200 bps. On the other hand, dedicated services are good for a company which uses the channel more than one hour per/day. The reliability of this service is better than dial-up. The telcos are responsible for the quality of service, and they maintain the line on a regular basis. The recommended transmission speed of this service can go up to 2400 bps. Cost of this service is fixed,

with an initial charge for installation and a fixed monthly charge (Table I) that depends on the distance of the link between the two stations that are connected.

2. Dedicated Digital Service

This service is offered by a private company, PT. Lintasarta, which is a subsidiary company of PT TELKOM, specializing in data communications. The transmission channel from the customer premises is again a regular UTP telephone line, but with specific adjustments/modifications to meet the requirements of digital data transmission.

The Digital over Voice technology (Lintasarta2, 1993) is a digital based technology over twisted pair cable. Both voice and data can be sent together over the same cable. Data is superimposed in the line above the voice using TCM (Time Compression Multiplexing) (See Figure 16).

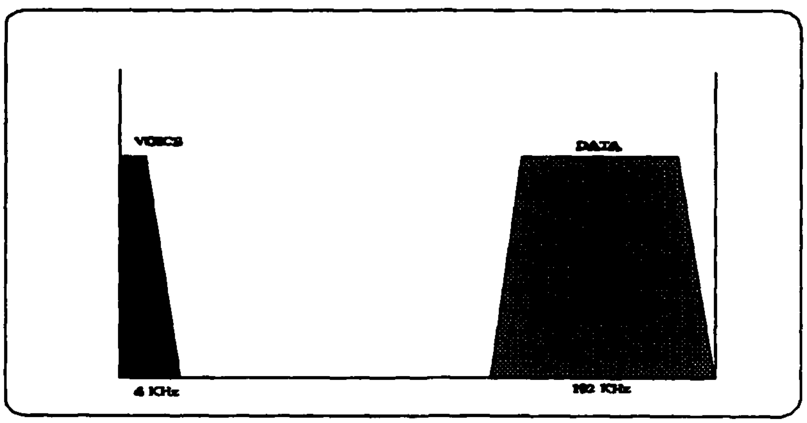

Figure 16. DOV Technology

The data transmission speed is 4800 bps up to 64 Kbps; the higher the data rate the more expensive the cost.

Customers can get this service for permanent usage with a monthly charge or for temporary usage (less than one month) with a daily charge; both usage methods must also pay the same initial charge for the installation of the Digital Over Voice equipment (Table 1) in the customer's premises.

C. VERY SMALL APERTURE TERMINALS (VSAT)

Indonesia lies neatly along the equator where geostationary satellites are well established in outer space. Satellite communication provides one of the best solutions to integrate the Indonesian archipelago. Today, the PALAPA B2R satellite is currently owned and operated by PT TELKOM. This satellite communication system is the basis for the Very Small Aperture Terminals (VSAT) services. VSATs have small antenna apertures, from 0.6 m to 2.4 m in diameter. A VSAT system is considered to be a low cost system and is easy to install anywhere throughout the country. VSAT is also known as the Personal Earth Station (PES) due to low transmission and reception power (because of the small aperture antenna). In order to communicate from one VSAT site to another VSAT site, each VSAT must transmit through a central hub (bigger earth station) to boost up the signal power to the destination. This is like a star topology where data transmission is controlled through the central hub station (Fig. 17).

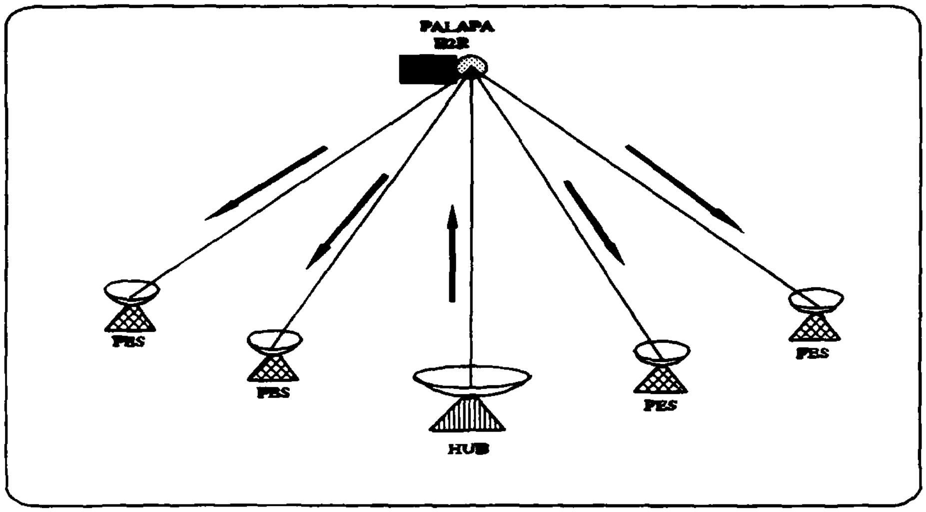

Figure 17. Star Topology

VSAT systems in Indonesia operate in the C-Band frequency range, using 6 GHz for uplink and 4 GHz for downlink. There are two possibilities for the Army to establish data communications, via VSAT LINTASARTA or VSAT DOD.

1. VSAT LINTASARTA

PT Lintasarta offers data communication service through a satellite system that is rented from PT TELKOM. PT Lintasarta provides an earth station as a hub and VSATs that will be installed in the customer's premises. Data rate is 4,800 bps up to 19,200 bps. Two types of services are available, depending on the way the customers communicate with each other (Lintasarta3, 1992).

- Single hop configuration. Data is transmitted from VSAT up to the satellite and reflected back to the hub station and then sent to the customer office through local link or

vice versa using one single trip through a satellite (Fig. 18). In this case the central computer must be in Jakarta (because the hub station is located in Jakarta). This configuration is good if there is no need for direct communication among VSAT sites or among branch offices using VSAT services.

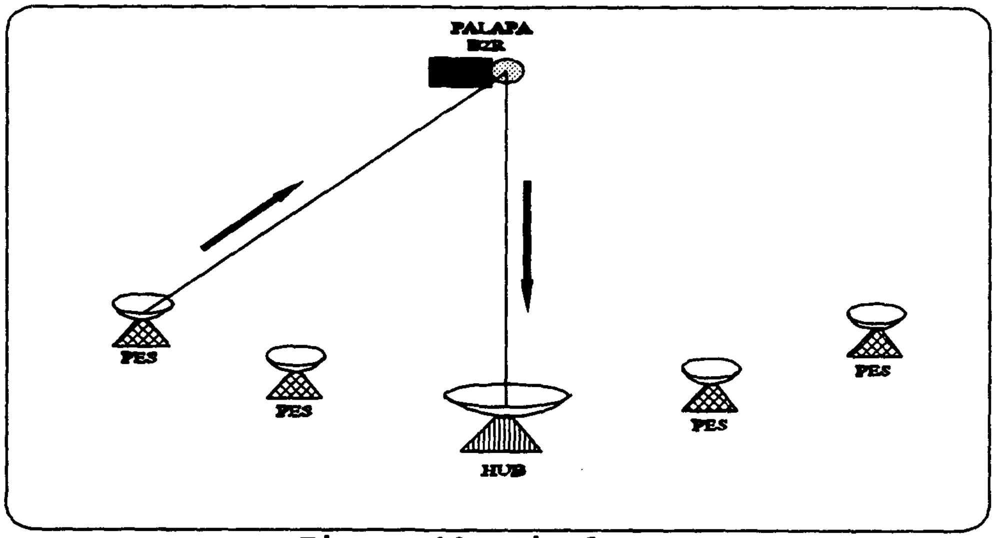

Figure 18. Single Kop

- Double hops. Data is transmitted using two trips through a satellite from one site to another site (Fig. 19). Data is transmitted from one VSAT through satellite and then received by hub station, which then sends the data back to the satellite to be reflected to its destinations.

2. VSAT DOD

The DOD Communication Agency also has its own transponder in the PALAPA satellite for administrative communication purposes. This channel can carry voice, telex,

and data. The whole channel has been divided and allocated to the Army, Air Force, Navy, and DOD itself. VSATs are already installed in all of the Main Region Military Command, co-located with the primary data computers. It would be difficult to set aside or rearrange the channel allocation for new Army data communication services, but there remains an opportunity to share the assigned channel.

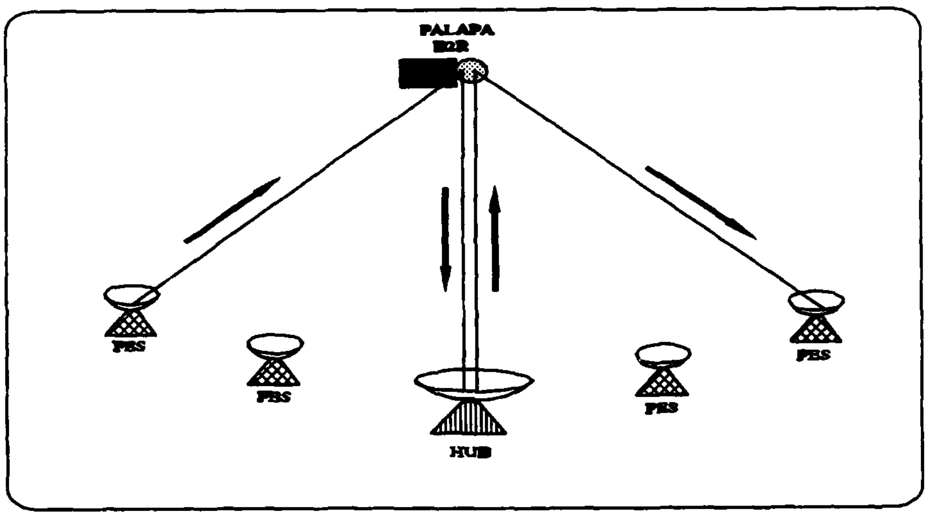

Figure 19. Double Hop

D. RADIO LINKS

Another possibility is to implement data communication over radio links. These can be microwave links (Very High Frequency, Ultra High Frequency) or High frequency (HF) links, depending on the geography of the location. Most radio links currently installed have specific uses, and there is no private company who provides commercial radio communication services. It is not considered to build military radio links for Army data communications for now.

IV. NETWORK DESIGN AND IMPLEMENTATION

A. PRELIMINARY VIEW

The current Army's information system consists of hardware, software and data transfer procedures that are relatively outdated and depend on little network connectivity. As technology advances rapidly, most of the hardware is already obsolete and new hardware must be purchased. The software and procedures would also have to be changed to support the new hardware and network infrastructure.

1. Hardware

In the near future, the Army will no longer keep and maintain the current mainframe and minicomputers because the costs outweigh the benefit of operating those computers. The rapid growth of small computers, the expanding use of client/server methodology and the widespread implementation of Reduced Instruction Set Computer (RISC) technology seem to dictate the replacement of the current system. The Army's information system management has decided an overall policy as follows:

- Implement a LAN-based client/server system at the Army HQ and at every Main Region Command.
- The server will use a powerful workstation based on RISC technology.

2. Software

The conversion of application software from the current platforms to any new computer system is a critical ingredient. Previous software must be reengineered and recoded for the new system, because of nonportability of programs. The data structure must also be converted to suit the new environment. The legacy data maintained under the existing hardware and software may impede the development of effective and flexible new software. For this reason, data must be reorganized -- preferably in relational database --so as to better support the development of new software.

3. Data Transfer Procedure

The general data transfer procedures in use with the current applications will initially remain the same with the new system. Courier service will still be used to send data from the Army Military Region Commands to the Army HQ. Eventually the Army's information system management foresees electronic data communications instead of courier service to transfer data.

B. DEFINE THE REQUIREMENTS

The network that was first developed was unable to fulfill the requirements and is now obsolete when compared to data communication equipment and computers currently available today. The general requirements for computer communication are:

- Provide peer to peer connections from the Army HQ to each Army Region Command.
- Provide capabilities for remote login, electronic mail exchange, and file transfer.
- Support distributed processing in the future.

Several issues must be considered to fulfill these requirements in the areas of hardware, software, interfaces, and the communication carrier.

1. Hardware Concerns

The current hardware platform uses proprietary standards and would be difficult to upgrade to use open system standards. Any new hardware selection must satisfy the interconnectivity requirements or use an open system architecture. The hardware should support ISO OSIRM or TCP/IP protocol standards. Most manufacturers provide some options to support various levels of interconnectivity, but use of a proprietary protocol will cost more than use of an open system standard.

2. Internetworking Issues

How to interconnect networks or network segments to form an integrated network infrastructure is a critical issue for network design and implementation. The internetworking equipment that will be required are as follows:

• Bridge. This is a device to connect between networks that use identical protocols. It functions at the physical and data link layers of the OSIRM (Fig. 20). The bridge filters a packet for a local network destination or forwards it across the bridge for non-local destination addresses. It works very fast because there is no need for reformatting. The bridge simply reads a destination address and makes the decision to filter or forward the packet. Bridges can have different types of cabling interfaces; for example, an Ethernet LAN with coaxial cable can be bridged to a second Ethernet LAN that uses twisted pair wire (Schatt, 1992, p 68).

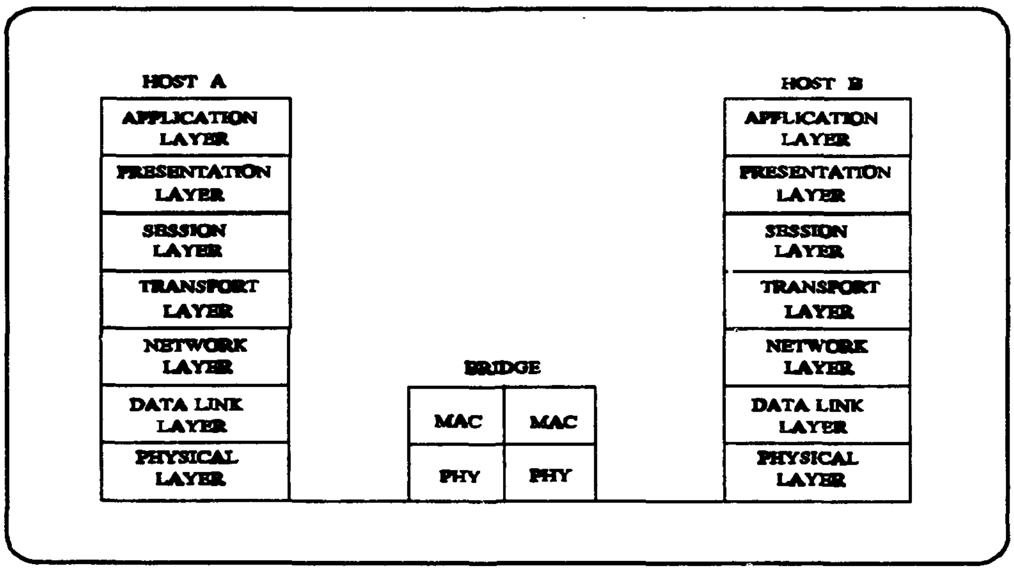

Figure 20. Bridge

• Router. This device is used to communicate between networks operating with different protocols (Fig. 21). A router protects one network from packets generated by another network, reducing message traffic. Before transmitting a packet to its destination, the router analyzes current traffic condition and determines the best route for its packet to take (Schatt, 1992, p 70).

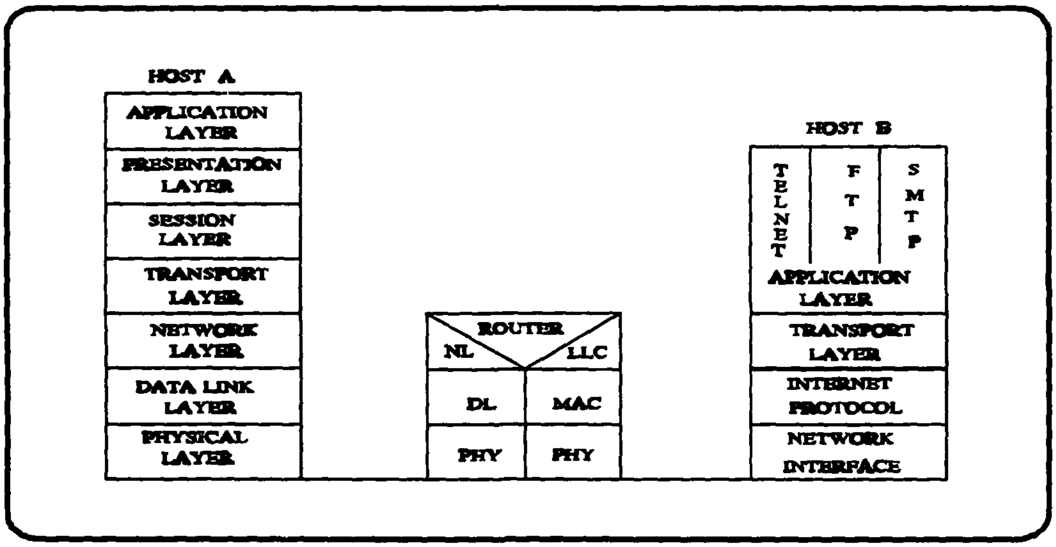

Figure 21. Router

3. Communication Carrier Selection

The issues behind communication carrier selection are: security, reliability, and cost. Alternative facilities that are currently available are listed and evaluated in terms of security, reliability, and cost in Table II.

Analysis of the communication options:

- PSTN. The reliability is very low compared with other services; the telephone company claims it is not responsible for errors. Providing security over PSTN would be very expensive.

TABLE II. COMMUNICATION CARRIER RELATIVE MERITS

TYPE OF SERVICE	MEDIA	SECURITY	RELIABILITY	COST
PSTN	UTP	1	2	2
Dial-up PSPDN	UTP	2	3	2
Leased PSPDN	UTP	2	3	3
DOV	UTP	3	4	5
VSAT Lintasarta	Satellite	3	5	5
VSAT DOD	Satellite	3	5	2

Scales:

1	2	3	4	5
Poor		Good		Excellent
Inexpensive		Expensive		Very Expensive

- PSPDN. The reliability is good; the network provider is responsible for transmission error. Security (encryption) must be applied to the data before it is transmitted through this media. The cost is cheaper for dial-up (20 hours/month) compared with leased line services.
- DOV. It is highly reliable, and the security is better too, but the cost is very expensive.

- VSAT Lintasarta. It is very reliable and security is higher than DOV, but the cost is very expensive.
- VSAT DOD. It is more reliable, more secure and even less expensive when compared to the VSAT Lintasarta. The DOD provide the service for the whole Indonesian Armed Forces.

It follows from this analysis that it would be best to have VSAT DOD as a primary option and dial-up PSPDN as a back-up system. As explained in Chapter II, VSAT DOD is already fully utilized, but there is a capability to rearrange/ optimize the channel by sharing with other users. While waiting for this channel to become available, dial-up PSPDN can be implemented. Once the VSAT DOD is available and operational, dial-up PSPDN can remain as a backup network to provide higher reliability for the army's computer network.

C. DESIGN THE SYSTEM

The design phase of the Army's data communication will be based on available information and some prediction. This design will cover specification, configuration, security concerns, and prototyping.

1. Specification

a. Hardware

Army's information and data processing centers will be provided with a local area network implementing client/server technology. The specification of the hardware

will vary due to the existence of multiple vendors and manufacturers. Most of the Army's DP personnel are familiar with IBM or compatible machines, but it would still be possible to use another machine such as Apple's Macintosh or RISC-based machine, if management decided.

b. Software

The specification of the operating system will be based on the hardware to be purchased. DOS is the most popular for the Army's current computer users. The LAN software that works well with DOS machines include Novell Netware, Banyan Vines, IBM PC LAN, and others. It is possible that one of the UNIX operating systems will be chosen to operate on a RISC based machine.

c. Internetworking Equipment

The communication devices that can connect between networks are bridges for the same protocol, and routers for different protocol. A bridge is cheaper than a router because it is less sophisticated and easy to provide.

2. Configuration

As the Army's organization is hierarchically structured, reports flow from lower to the higher level. The Army Military Region commands report directly to the Army HQ. There is no need to make horizontal reports or provide inter-regional coordination except in special cases. Two possible options are recommended to configure Army data communications.

The first option, once VSAT DOD is implemented, is to use single hop communication (Fig. 22).

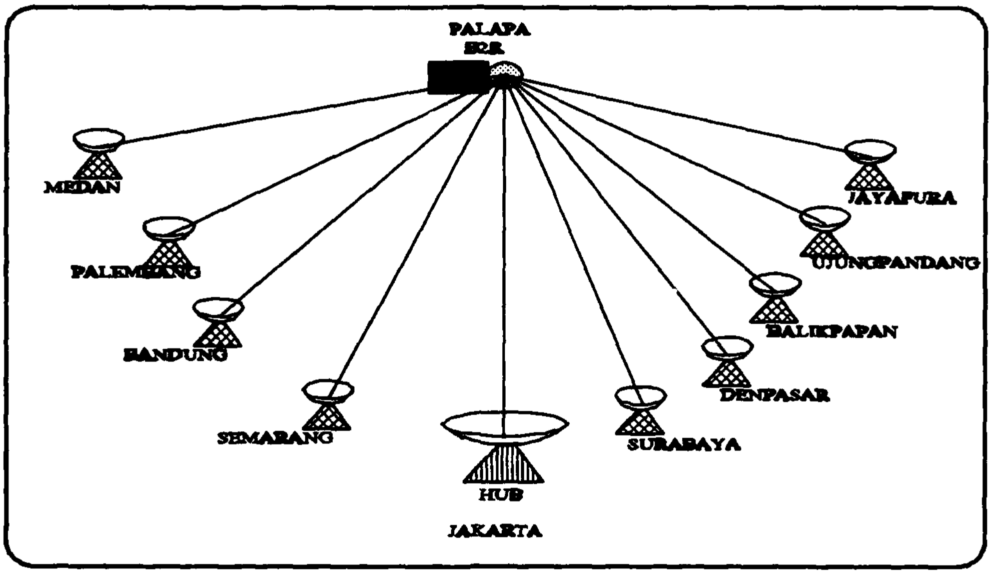

Figure 22. VSAT Based Networking

The reasons for implementing single hop communication are: 1) No horizontal communication is needed, i.e., no VSAT to VSAT communication is needed; 2) The hub is located in Jakarta, co-located with the Army's computer center; and 3) Single hop configuration is less expensive compared to double hop communications.

The second option is a configuration using dial-up PSPDN (Fig. 23). This is the second best data communication selection that would fulfill the Army requirements. The functions that can be implemented by this configuration are file transfer and electronic mail. Remote login is not implemented because it would unnecessarily increase the cost.

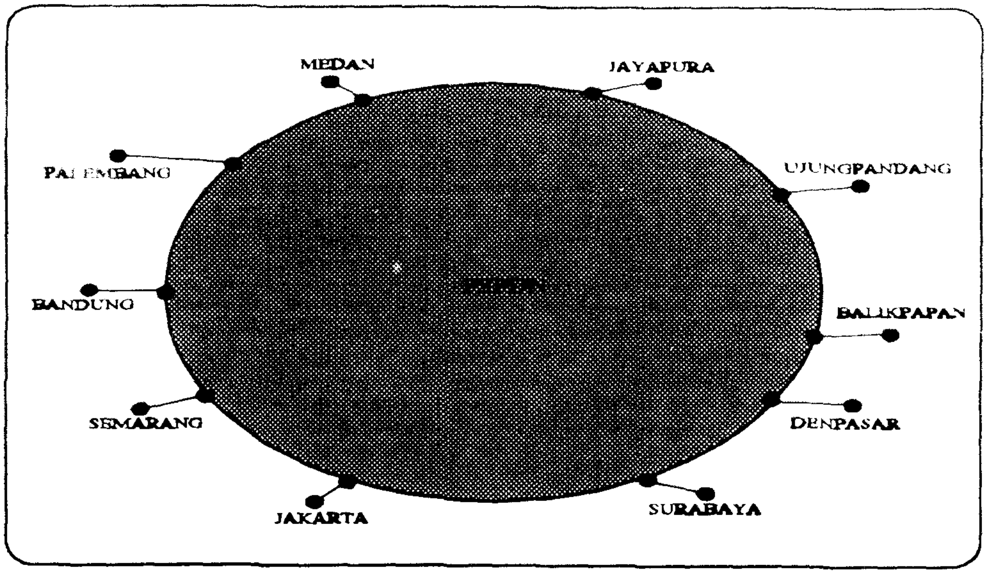

Figure 23. PSPDN Based Networking

3. Security Concerns

VSAT DOD is a secure network and is isolated from the public network. However, security concerns remain similar to those that would be taken for a public network.

Efforts must be taken to protect data from unauthorized users, especially intruders who use a dial-up telephone to connect to one of the Army's computer nodes. A call back system is a good way to reject the unwanted caller. In this system, the caller ID must be recognized by the node (by looking it up in an authorized user ID table) or else caller is rejected at the very first attempt.

To protect data over the communication lines, the use of a cipher machine is suggested. Data must be encrypted before going out to the communication link and must be decrypted when it reaches the destination address. The

processing speed of transferring data will be slower because it must be coded and decoded, but this is a cost of the security that must be paid.

4. Prototyping

A small investment in an experimental prototype will save time and money. The prototype system can be built locally and simulate the network using minimal resources. One ideal test site is Jakarta with its existing local area network; another LAN can be created to simulate another site. A dedicated computer to act as a bridge is needed to connect these two LANs (Fig. 24). The bridge is not a user-computer and is transparent to the user. It is simple and less expensive than a router.

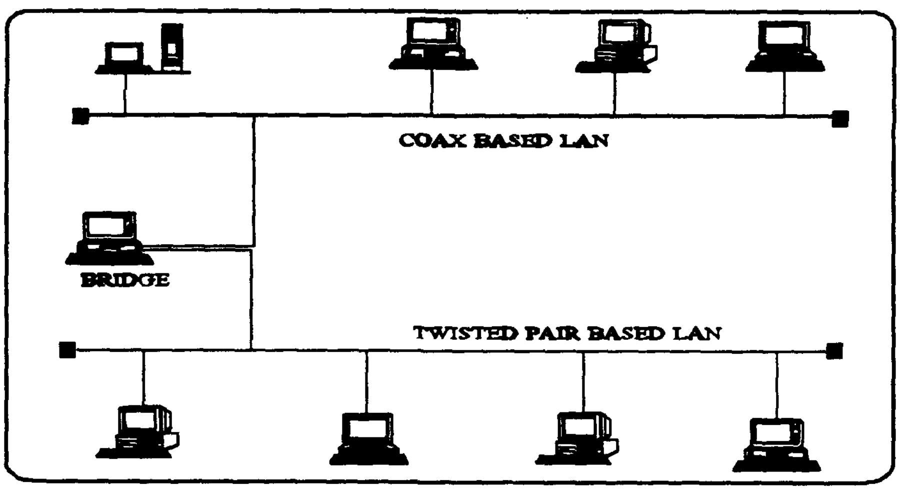

Figure 24. Bridge Connection

Bridge is chosen because typically the Army data processing centers perform uniform tasks, using pretty much the same

application program. It would be wiser if management provides the same computer platform and same operating system and build the same LAN system in the prototype as in the full development. The only difference is the size of the storage and the number of peripherals that are going to be used by each site. This policy will save the Information Technology human resources, development time, and learning process. Alpha testing (test by designer) must be done in this phase, even though it is using a prototyping system.

D. IMPLEMENT THE SYSTEM

There are nine remote locations and a computer network that will be implemented. Even though prototyping and alpha testing are done already, problems in the real installation still will probably occur. To prevent wasting time and effort, it is good to have a time schedule for the implementation. An example is shown in Table III.

1. Install Hardware and Software

The procurement system is centralized in the Army DP center. The hardware and software will be purchased in Jakarta and then distributed to the Army's Main Region Commands and Branches. While still in Jakarta, these computers must be checked and tested using both system software and application software. Testing can be done similarly to the prototyping; once all systems pass the tests, they are shipped to the destination. These types of computers

are to be set up by customer; therefore local DP personnel, with technical assistance from the Army DP center, can install these computers.

TABLE III. TENTATIVE TIME SCHEDULE

LOCATION	TIME IN CONSECUTIVE MONTH					NOTE
	1-2	3-4	5-6	7-8	9-10	
JAKARTA	■					
BANDUNG	■					Every Two locations are connected to Jakarta
SEMARANG		■				
SURABAYA		■				
MEDAN			■			
PALEMBANG			■			
DENPASAR				■		
BALIKPAPAN				■		
UJUNGPANDANG					■	
JAYAPURA					■	

2. Testing

Site testing or beta testing (testing by the actual user) must also be accomplished. This testing includes the communication test. The period of testing is expected to last one month or less. The data communication tests should be done using different times and conditions and must be recorded. Analysis of this report will help determine the best time to transfer data from each Army branch to the Army DP center.

3. Training

Local DP personnel, especially those responsible for data transfer, must be trained. They can be trained together in Jakarta before their own computers are installed. Local training will still be needed and can be done simultaneously with the testing. This allows the personnel to have enough opportunities and experience with success and failure, and provide problem solving experience using real situations.

4. Operation

Parallel operations of both the current and the new system should be done at least for the first three months. One problem that arises during this parallel operation is that the current system and the new system are so different in the transmission media and time frame involved. The current system is manual (Fig. 25): file transfer uses courier services, and delivery takes several days to meet the deadline. The new system (Fig. 26) is fully electronic: file transfer uses electronic data communication, and delivery takes several minutes to meet the deadline. In this circumstance one possible solution is:

- First month: 1) Send data through the current system using courier service as the main method 2) Send data through the new system electronically as a comparison. This can take place in the current system schedule.

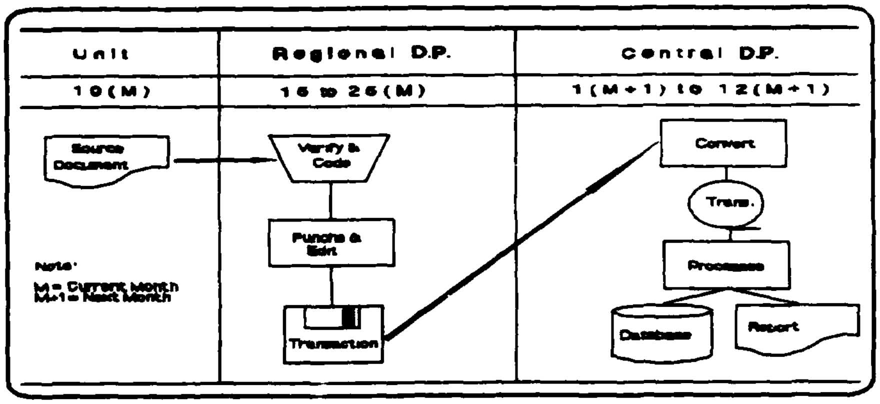

Figure 25. Manual Schedule

- Second month: 1) Send through the new system as main method. This can take place in the current system schedule. 2) Send through the current system as comparison by providing a hardcopy of the file that has been transferred.

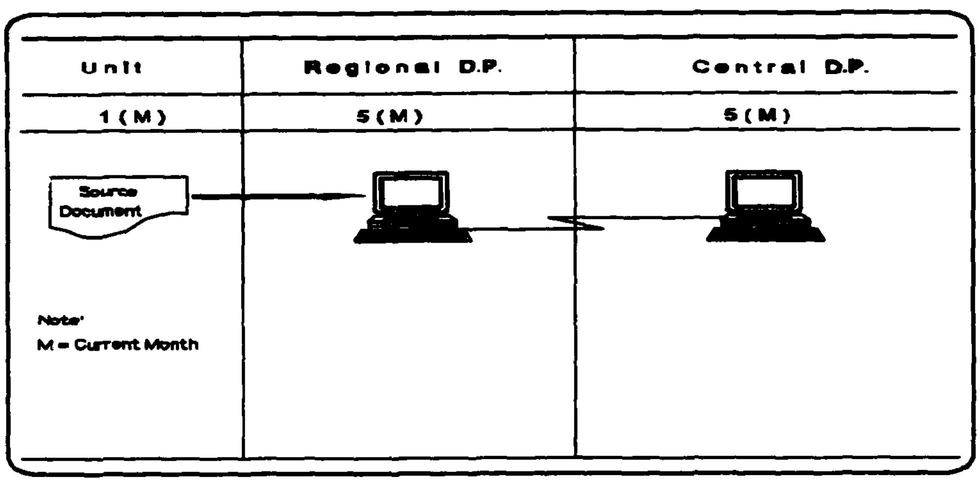

Figure 26. New System

- Third month: 1) Send the new system as main method; 2) Fax the hardcopy file to the same destination as a mean to verify if errors are occurring in the electronic file transfer.

For the fourth month and beyond, hardcopy fax is not necessary unless management decides differently.

E. MAINTENANCE AND IMPROVEMENT

These two activities are interrelated. Making improvements will provide needed maintenance, and if it is well maintained, improvements can be easily done.

1. Maintenance

- Record all data communication activities include date, time (start and finish), and number of records transmitted.
- Record all problems that occur in hardware, software, and communication facilities.
- Record how problem was fixed and the action taken, including date, time and result.
- Keep contact with the communication provider to maintain the transmission line condition.
- Report problems that can not be fixed to the higher level (local authority and Army DP center).

2. Improvement

- Construct simple statistics of the data errors that occur including time, number of errors, and number of records, to find out a way of improvement.
- Take action as necessary to improve the process, such as change the transmission time schedule for better results.

V. FUTURE ENHANCEMENT

In the last few years, technology has made dramatic advances in the computer and communication systems arena. The increase in processor speed from 8 Mhz to 100 Mhz has had a dramatic impact on the processing capabilities of any computer system. Digitizing the communication network changes the available rate of data transfer from 300 bps to 2 Mbps over a copper-based telephone line. Application demands also have kept up with the technology change, from a pure data processing environment to multimedia environments that make it possible to process data, text, voice and video together.

Advances in technology will continue indefinitely, and it is difficult to tell whether application demand or technology innovation is driving the changes. The Army's information system management personnel must be aware of and prepare for these technological changes that will affect the established computer network.

A. NETWORK EXPANSION REQUIREMENT

The Army's data processing center collects data from the smallest units in the remote area, such as Infantry Battalions, Sub-Region Military Commands and Sub-Army Branches. This data is sent to the Army Region Main Command

in the form of source documents, and then converted into electronic record data. This data is sent to the Army DP center through the computer network. Sooner or later computers will be required for those remote units in order to speed up local data processing preparation to support their higher command. This demand can be easily met because of the proliferation of small business computers, each now more affordable and more capable. One desktop computer set including a printer is sufficient for a unit in the remote area. The driving force behind this requirement comes from two directions:

1. DP community demand: As data is collected in the form of source documents, it needs to be coded and recorded into the computer. This process is time consuming and subject to human errors, like incorrect coding and typographic faults. To eliminate this problem, the data entry process can be shifted one step down to the field unit. Besides solving the problem of data entry at the DP center, it also increases the quality and timeliness of the data. Whatever changes occur in the field, the field unit will update the data promptly.

2. Unit command demand: In this information era, time has become more critical, inter-related data and information more complex, and decisions must be reached right away. The small business computer can help to process this

requirement. It is reasonable and logical for a unit command to be provided with a small business computer, because these unit commands are directly involved in the dynamic situation in the field.

The Army's information system management must be aware of those forces driving demand, and provide the solutions. They must also be prepared for the expansion of data communications. The remote computer must have the capabilities to login and transfer files to the Army Region Main Command and vice versa. The communication facilities must be provided as needed and must be integrated into the current data communications network.

B. APPLICATION DEMAND

Two major user requirements that could possibly emerge and have impact on the current computing and communication environment will be discussed: 1) management demands for information, and 2) need for distributed processing to satisfy Army Region Main Command and Branches requirements.

1. Management Level Demand

Use of a computer for data processing has been around for a long time. As the technology advances and user demands increase, computers are now more sophisticated, and can not only process the data, but also serve as an expert to provide a solution for a user. The evolution of types of computer

decision aids is related to the level of management in the organization (Turban, 1993, p 23).

As seen in Figure 27, the first generation of computer aids is Transaction Processing Systems (TPS) for the operational level and low level management; the second generation is Management Information Systems (MIS) for low level management and middle management; the next generation is Decision Support Systems (DSS) for middle management and top executive levels, and the fourth generation is Executive Information Systems (EIS) specialized for the top executive.

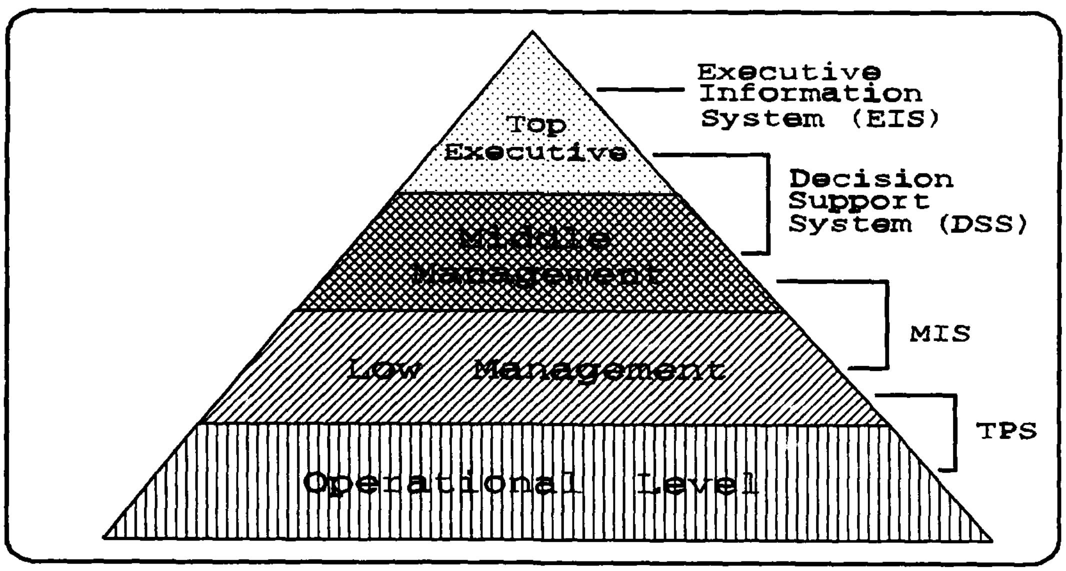

Figure 27. Organization Level and Computer Aids

Since today's Army DP center is in the era of MIS, it supports only up to the middle management layer. The Army Chief of Staff (ACOS) will have no direct involvement in using

the product of a DP center, and therefore receives no benefit. Therefore, the ACOS and middle management will need a DSS and EIS. DSS and EIS will feature integration of computer data, text, images, video, and voice together in this popular era of multimedia. The cu[illegible]rmy's computers and communication systems will not be sufficient to respond to this demand. Images and video signals occupy large bandwidth and have different bit rates compared to computer coded data. Multi-bit rate transmission is required to integrate this information demand. More computer capabilities and higher transmission bandwidth are required.

2. Distributed Processing Demand

Most of the current applications are centralized because of the current user needs, and the capability of the central computer is more powerful than those in the Army Region or Branches commands. This computer capability will probably not be changed since the central computer is required to be more powerful than the local computers to meet capacity needs. Central databases will hold more data and information than local databases. As the local application demands increase, data interdependency will necessarily occur. Local processing will need data stored in the central computer, so distributed processing will emerge. Distributed Processing is considered processing an application on more than one computer (Sprague, 1993, p 147). The Army's information system

management must be aware of this trend that will affect data communication facilities, since it needs high speed data rate transfers and specific computer connection protocols.

C. COMPUTER TECHNOLOGY ENVIRONMENT

Since the invention of microchips, computers have become smaller, faster and lightweight. Portable computers bundled with communication equipment will drive mobile computing to provide businesses more flexibility to access main computers in the office. This trend of computer technology will affect the way the ACOS and his staff can retrieve information from the main computer while they are out of the office. Cellular phones are becoming available in most major cities in Indonesia. This technology will drive wireless data communication to become easier and more reliable. Wireless data communication technology is still being developed to solve the problems of fluctuations, multipath propagation, dead spots, and radio frequency shadows which create high errors and cause data rates to drop dramatically (Miller, 1994, p 62).

Army's information system management must be aware of providing these capabilities, whether integrated with the current computer network or not. If the service is to be integrated with the current system, some means of integrating wire and wireless data communication must be provided.

D. COMMUNICATION TECHNOLOGY ENVIRONMENT

Fiber technology is becoming a major trend for the carrier medium in the communication industry. It provides wide bandwidth, error free and high speed transmission. Some trunk cables are already using fiber optic cable. Sooner or later this fiber optic cable will be brought directly to the customer premises. The higher capacity bandwidth that can be carried by fiber optic will provide room for the revolution of the communication system, leading to implementation of Broadband-ISDN as discussed in Chapter III. With B-ISDN, ATM technology will play a significant role in providing multirate data transfers such as data, video, text, and voice together in the same network (Soneru, 1993, p 29).

Army's information system management must foresee this emerging technology that can be applied to the Army computer network to solve the information demand in multimedia applications.

VI. CONCLUSION

A. SUMMARY OF RESEARCH

The results of the research are summarized below as answers to the original research questions:

- The Army's existing network protocol is IBM's SNA. Since the IBM mainframe computers are being phased out, and new computers will be purchased to support a LAN-based client/server architecture model, the SNA protocol will no longer be used. The Army's information system management has decided to implement a client/server architecture with a RISC based machine as a server on a LAN within each major command. The network protocols will be non-proprietary protocols such as OSI or TCP/IP.

- The new wide area network configuration should follow the Army's organizational structure and should use a star topology. Since there is little information exchange or interdependency between individual LANs, the star topology is deemed the best. If for some reason a different topology is desired, the multidrop topology is the most economic.

- The most appropriate transmission medium for long haul connectivity is satellite nications using a single

hop mode. Co-locating a hub station control center with the Army EDP center in Jakarta provides communication using VSAT to all major sites that are connected to Region Main Command. Circuit switching mode will be the most economical and is feasible with this communication system; connections must first be established before data transmission can take place.

- There are three different network providers: PT Telkom, a state-owned telecommunication company responsible for telephone services; PT Lintasarta, a subsidiary of PT Telkom which specializes in data communication; and DOD Telecommunication Agency, which provides telephone, telex, faximile, and data communication services. DOD is the first choice as a primary network and PT Lintasarta is secondary choice for a backup system.

- Future technological trends that management must foresee are: 1) Growth of the network will follow as computers are installed in every small unit command in the field; 2) The demand for multimedia in applications will require multirate data communications and have a great effect on the network; 3) Advances in computer communication technology, especially the implementation of B-ISDN, will provide great opportunities as well as challenges.

B. CONCLUSION

There are many areas where improvements can be accomplished in the Army's information quality. One major improvement can be achieved by changing the way data is communicated between Army commands from manual transfer to electronic transfer. The difference in data integrity in terms of how data in the Army EDP center is compared to the actual condition in the field is currently measured in days; this can be reduced to seconds or even real time if needed using electronic data transfer.

Communications between LANs must use either a bridge for the same protocol or a router for different protocols. These two types of components must be properly identified and included in the procurement processes. Otherwise, problems will be encountered in implementation.

DOD VSAT privately owned communication network can support the requirements of Army data communications. Computer installations are co-located with the VSAT hub and other VSAT sites, so minimal effort will be required to connect computers to the VSAT network. PT Lintasarta, as a data communication provider specialist, can provide an alternative facility that can be used now until DOD VSAT becomes availabe.

C. RECOMMENDATION

Standards must be determined, applied and enforced when selecting and buying hardware and software. Avoid use of

proprietary standard as much as possible; this will support future upgrades to the system as new emerging technologies become available. A standard will save the EDP human resources, time and money. Use of a standard allows one particular application software to be interoperable. Ensuring communication between LANs becomes almost a trivial matter when open standard protocols are used.

Choose DOD VSAT as the primary communication medium, even though it is shared with other services. Use PT Lintasarta's PSPDN called SKDP in dial-mode as a secondary means for backup purposes to provide reliability. While negotiating and working with DOD VSAT to obtain channel assignments, SKDP can be used because it is already available.

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